Lake Sawyer Water Quality

A Report on Water Quality Monitoring Results
for Water Year 2012 at Lake Sawyer

Lake Sawyer *taken in 2012 by Sally Abella*

Prepared for the City of Black Diamond
by the King County Lakes and Streams Monitoring Group
Science and Technical Support Section,
Water and Land Resources Division
King County Department of Natural Resources and Parks

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King County

Overview

The King County Lakes and Streams Monitoring Group (KCLSM) and its predecessor the Lake Stewardship Program collaborated with citizen volunteers to monitor Lake Sawyer between 1993 and 2004. Since 2006, the City of Black Diamond has contracted with KCLSM to continue monitoring Lake Sawyer. Lake water quality monitoring is done on a schedule of once per month between May and October, versus the typical schedule of every other week for other lakes in the program. The water quality data indicate that currently the lake has moderate productivity (low mesotrophic) with good water quality. Inlet water quality is routinely monitored once per month between November and May, with a goal of 2 storm sampling events per water year.

There is a public boat launch and a large regional park adjacent to the lake that allows members of the public to access for recreation and to launch boats. Lake users should track aquatic plants growing near shore to monitor Eurasian watermilfoil and to catch early infestations of Brazilian elodea or other noxious weeds.

This report refers to two common measures used to predict water quality in lakes. The Trophic State Index or TSI (Carlson 1977) is a method of calculating indicators from collected data that allows comparison between different parameters and predicts the volume of algae that could be produced in the lake. A second measure is the nitrogen to phosphorus ratio (N:P), which is used to predict what groups of algae may become dominant in the lake during certain periods. Both the TSI and N:P ratios have been calculated using the available data collected through the volunteer monitoring program.

The discussion in this report focuses on the 2011 water year. Specific lake data used to generate the charts in this report can be downloaded from the King County Lake Stewardship data website at:

http://www.metrokc.gov/dnrp/wlr/water-resources/small-lakes/data/default.aspx.

Data can also be provided in the form of excel files upon request.

Physical Parameters

Secchi clarity and water temperatures were gathered by volunteers monthly from May through October 2012. Physical parameters were recorded each time water samples were collected through the sampling season.

Secchi transparency is a common method used to assess and compare water clarity. It is a measure of the water depth at which a black and white disk disappears from view when lowered from the water surface.

For Lake Sawyer, Secchi transparency values ranged from 2.8 m to 5.0 m, averaging 3.7 m (Figure 1). These values suggest that Lake Sawyer transparency has been generally stable over the last few years and definitely much clearer than during the mid to late 1990s after diversion of the experimental sewage plant effluent to the upstream wetland.

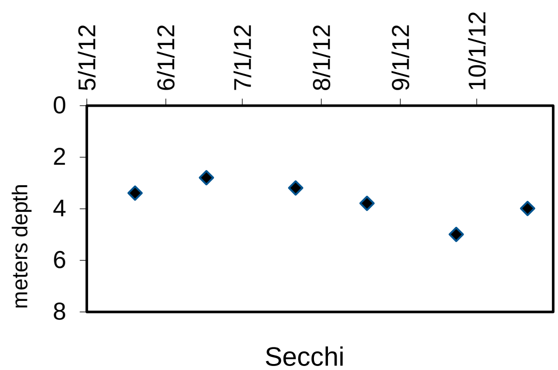

Figure 1. Lake Sawyer Secchi Transparency

Water temperatures during the sample period followed a pattern similar to other lakes in the region, with temperatures warming to summer maximum temperatures occurring between mid-July and mid-August, and temperatures cooling in the fall. The temperatures through the sampling season ranged from 13.5 degrees Celsius to 24.0 degrees Celsius with an average of 19.3 (Figure 2). The maximum temperature was in late August, reflecting the slow warming in 2012 related to a cool and wet spring/early summer.

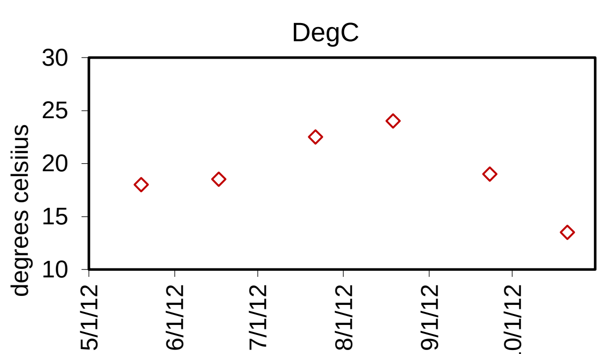

Figure 2. Lake Sawyer 1 meter Water Temperatures

Mean summer water temperatures over the years that Lake Sawyer has been monitored have varied from year to year, but show no statistically strong trend toward change through time (Figure 3).

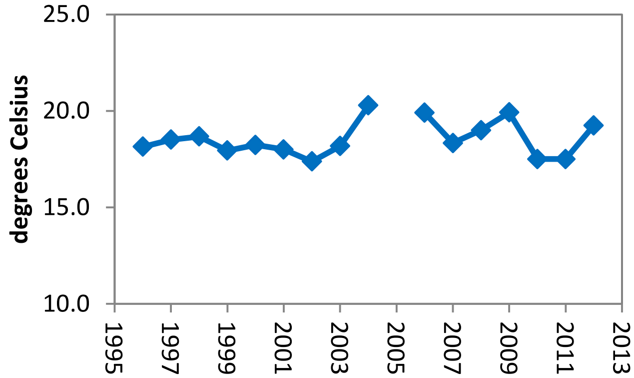

Figure 3. Mean May – October 1m water temperatures for Lake Sawyer

Nutrient and Chlorophyll Analysis

Phosphorus and **nitrogen** are naturally occurring elements necessary in small amounts for both plants and animals. However, many activities associated with residential development can increase concentrations of these nutrients beyond natural levels. In lakes of the Puget Sound lowlands, phosphorus is often the nutrient in least supply, meaning that biological productivity is often limited by the amount of available phosphorus. Increases in phosphorus concentrations can lead to more frequent and dense algae blooms–a nuisance to residents and lake users, and a potential safety threat if blooms become dominated by species that can produce toxins. Samples collected by volunteers are analyzed for total phosphorus (TP) and total nitrogen (TN) concentrations at one meter depth.

In 2012, the TN started at its maximum and decreased slowly, remaining stable with one small variation after July (Figure 4). TP values followed a similar pattern, but increased more in the latter part of the monitoring season. Note that the scale for TN is 10x that for TP.

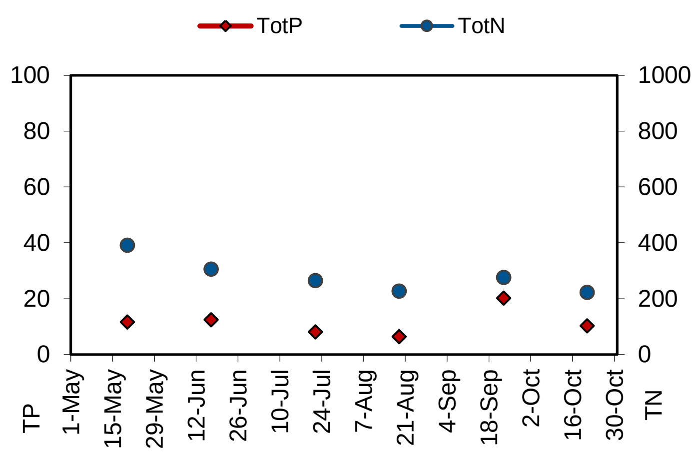

Figure 4. 2012 Lake Sawyer nutrients at 1 meter in ug/L.

The ratio of nitrogen (N) to phosphorus (P) can be used to determine if conditions are favorable for the growth of cyanobacteria (bluegreen algae) that can impact beneficial uses of the lake. When N:P ratios are below about 25, cyanobacteria can dominate the algal community due to their ability to take nitrogen from the air.

The N:P ratio ranged from 13.7 to 35.9 with an average of 27.1 (Figure 5), which suggests that nutrient conditions were often favorable for nuisance bluegreen growth. However, the overall low values for phosphorus may prevent large nuisance cyanobacterial blooms from forming.

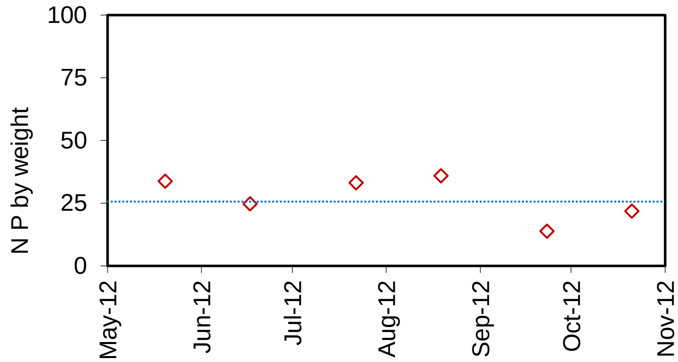

Figure 5. 2012 Sawyer Total Phosphorus and Total Nitrogen Concentrations. Values below the blue line indicate a potential nutrient advantage for cyanobacteria.

Chlorophyll *a* values were relatively low throughout the monitoring season in Lake Sawyer (Figure 6), with the maximum value occurring in mid-May at the beginning of the sampling season. These low levels reflect phytoplankton volumes in the surface water mid-lake, but do not preclude the possibility of accumulations of buoyant algae colonies along shores that are downwind. Pheophytin (degraded chlorophyll) remained near the level of detection throughout the majority of the season.

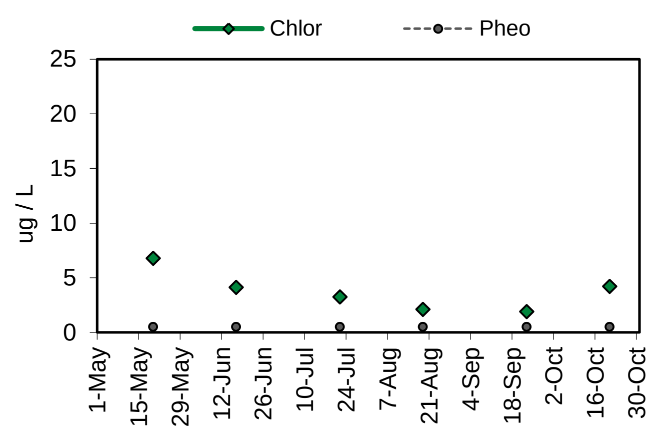

Figure 6. Lake Sawyer Chlorophyll *a* and Pheophytin Concentrations

Water column profiles

Profile temperature data indicate that thermal stratification was present by May and persisted through the summer (Table 1). In the bottom samples for both May and August there were elevated levels of NH3 (ammonia) present, indicating that the hypolimnion (bottom water) of Lake Sawyer is low in oxygen early in the summer season and progresses towards anoxia, which may cause release of phosphorus from the sediments. This internal loading was apparent in the August bottom sample, in which Total P was significantly higher than it was in May. In addition, more dissolved phosphate (OPO4) was present in the hypolimnion in August, further demonstrating that the anoxic conditions in the bottom water were causing some internal phosphorus release from the sediments. However, the amount of OPO4 in the deep water was not very large and, when mixed through the lake with fall overturn, would not greatly increase available phosphorus for phytoplankton growth

Table 1. 2012 Lake Sawyer profile sample results. Secchi and Depth in meters. Temperature in degrees Celsius. Chlorophyll and Pheophytin in ug/L. Nitrogen, phosphorus, and alkalinity in mg /L. UV254 in absorption units. Sample values below minimum detection level (MDL) are marked in bold, red with the MDL value.

Lake name	Date	Secchi	Depth	DegC	Chlor-a	Pheo	Total N	NH3	Total P	OPO4	UV254	Total Alk
Sawyer	5/20/12	3.4	1	18.0	6.76	**0.5**	0.391	**0.005**	0.0116	**0.002**	0.0911	59.8
Sawyer			8	7.5	8.85	1.1	0.558		0.0111			
Sawyer			16	7.0			0.551	0.124	0.0177	0.004		
Sawyer	8/19/12	3.8	1	24.0	2.08	**0.5**	0.226	0.006	0.0063	**0.002**	0.049	61.1
Sawyer			7	9.0	9.17	**0.5**	0.388		0.0164			
Sawyer			14	7.0			0.523	0.114	0.0386	0.0146		

The UV254 values indicate clear water, suggesting that there was little dissolved organic carbon in the lake. The alkalinity value is moderate and suggests that lake contains enough dissolved salts to be able to buffer pH changes better than many lakes in the region.

TSI Ratings

A common method of tracking water quality trends in lakes is by calculating the "Trophic State Index" (TSI), developed by Robert Carlson in 1977. TSI values predict the biological primary productivity of the lake, based on measurements of water clarity (Secchi) and concentrations of Total P and chlorophyll *a*. There are 3 categories of productivity: oligotrophic (low productivity, below 40 on the TSI scale); mesotrophic (moderate productivity, between 40 and 50); and eutrophic (high productivity, above 50).

TSI-indicators are created by averaging all 1m data collected for May through October. The TSI for Total P was lower than the other two indicators, placing in the high oligotrophic range, similar to a few of previous years (Figure 7), although it showed a small increase from 2010. The average TSI for Secchi increased slightly, though the TSI for chlorophyll decreased; both are in the mid to low mesotrophic range. The average of the indicators in 2011 placed the lake just above the mesotrophic threshold, very similar to where it has been since 1998.

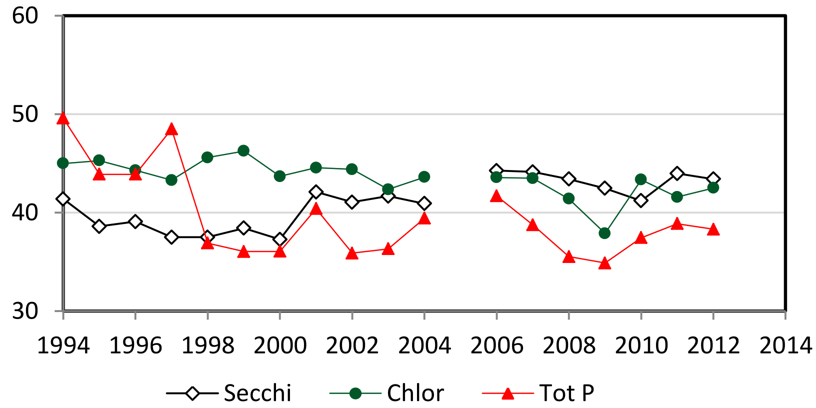

Figure 7. TSI Values for Lake Sawyer over time. TSI values are comparative numbers that do not have associated units of measure.

TMDL

The Total Maximum Daily Load for Lake Sawyer set by the Washington Department of Ecology in 1993 defined a goal of an average of 16 ug/L total phosphorus concentration for the lake, but did not include the time period or water depth for which this was to be calculated (epilimnion vs. whole lake). A wasteload allocation of zero was set in accordance with the removal of the Black Diamond wastewater treatment plant discharge to the wetlands feeding Rock Creek. A total annual influx of 715 kg phosphorus from the inlets was estimated to meet the 16 ug/L average concentration target. Load allocations for tributary input was set at 511 kg/yr and internal loading input at 124 kg/yr, with 80 kg/yr allowed for other sources such as direct runoff and dust fall.

Onwumere (WDOE publication 02-02-054 December 2002) found that Lake Sawyer appeared to be meeting the TMDL target as a long term average, but noted that it might not be meeting a maximum in-lake mean summer target. The Lake Sawyer Water Quality Implementation Plan (June 2009) noted that significant urban growth was scheduled for the area and that such development had the potential for impacting water quality in the lake.

The long term data set collected by King County and trained volunteer monitors begins in 1985 and continues to date, with a one year gap in 2005. Average June–September 1 m values (Figure 8) show that there were a number of years around the time of the decommissioning of the sewage treatment plant when summer average phosphorus concentrations were higher than in previous years and were generally above the TMDL goal. However, since 1998 the values have been similar to the late 1980s and have shown no cause to believe that the lake has not been meeting the standard set in the TMDL. There were small increases each year between 2007 and 2011, but a decrease in 2012 may signal that the change in values from year to year values are due to variability rather than a trend.

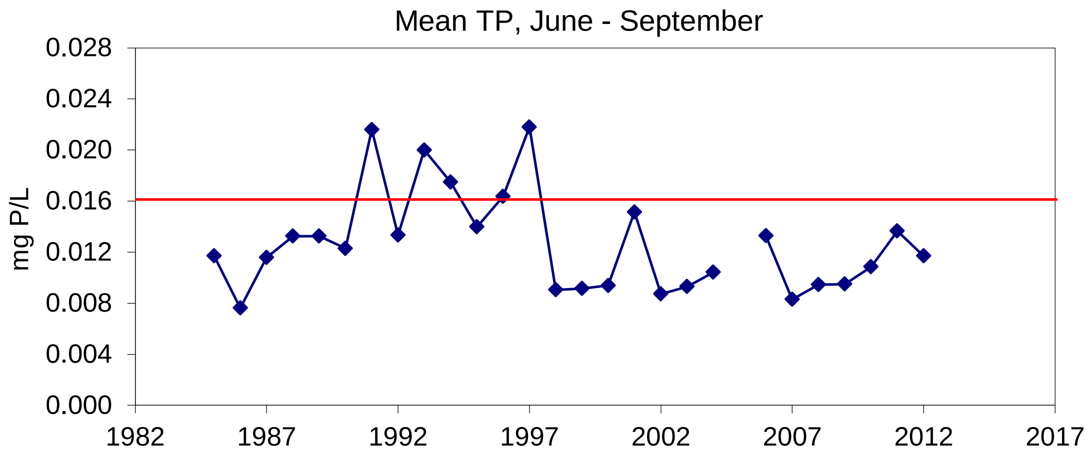

Figure 8. Summer average total phosphorus at 1m depth at Lake Sawyer. The red line represents the TMDL target of 16 ug/L.

The data continue to be encouraging, suggesting that Lake Sawyer continues to meet the TMDL and has been doing so for over 10 years. However, because significant land development in the watershed is expected to occur in the near future, it is important to continue monitoring to look for changes as it proceeds, as well as for some time afterwards, in order to be sure that the stormwater controls are effective in meeting water quality goals and targets.

Inlet Water quality

A second monitoring effort beginning in 2006 has focused on the water quality of the major streams flowing into Lake Sawyer during the wet season: Rock Creek (station LSIN1) and Ravensdale Creek (station LSIN9). The program consists of sampling once a month by volunteers and city staff beginning in 2008 when needed at the creek mouths during the wet season (generally November through May) when both creeks are flowing heavily. At the same time, water flowing from the lake at the outlet weir is also sampled (LSIN10). An additional goal was set of sampling one to two storms a year if possible, but this has not been accomplished in all years.

Volunteers were trained and city staff available to take the routine samples at 3 sites and were provided with prepared sample bottles and equipment. Samples were submitted to the King County Environmental Laboratory for analysis. Parameters measured included specific conductivity and total alkalinity as indicators of development, total phosphorus and orthophosphate for TMDL monitoring, total suspended solids, temperature and water stage for flow calculations. For storms, oil and grease are added to the routine data collection for the 3 main stations, and 5 stations more are sampled in addition.

Total alkalinity and Specific Conductivity

Specific conductivity measures the amount of dissolved salts in water by measuring the current-carrying capacity of the sample at 25 degrees Celsius. Total alkalinity, also known as "acid-neutralizing capacity", measures the amount of calcium carbonate equivalents in the water that act as a buffer, thus moderating pH changes. It is closely related to the "hardness" of the water.

In general, both specific conductivity and total alkalinity are tied to the soil types and rocks found in the drainage basin. Both parameters generally increase in surface waters as a basin is developed because of soil profile disturbance, as well as concrete emplacement and the importing of foreign fill soils, (often sub-soils with more mineral salts content than native top soils). Because of this, both parameters can be used as indicators of development over time.

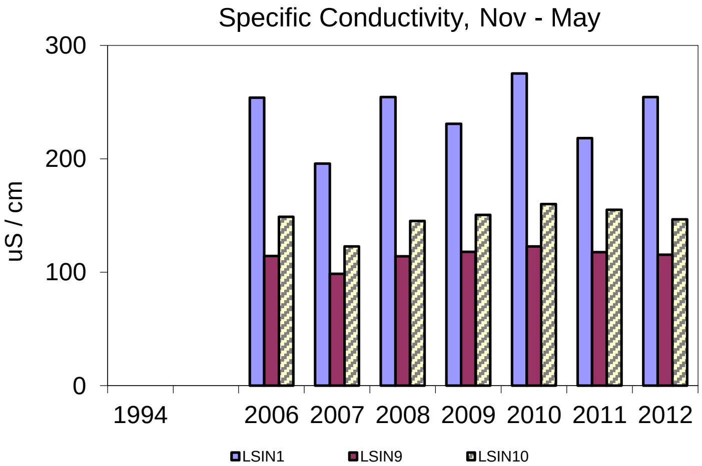

Figure 9. Wet season average of specific conductivity for Lake Sawyer and inlets

Rock Creek (LSIN1) is much higher in specific conductivity than Ravensdale each year (Figure 9), while water from Lake Sawyer at the outlet appears to be a mixture of the two, but is somewhat closer to Ravensdale in value. The hydrological model constructed in the 1990s for the Lake Management Plan assigned more inflow from Ravensdale Creek to the lake than from Rock Creek, based on the hydrological measurements taken in 1993-1994. Therefore, if the model is correct, the water from Ravensdale with lower specific conductivity would have a greater effect on the specific conductivity of the lake than the smaller inflow with higher specific conductivity from Rock Creek. This is also consistent with present land use in the two basins; in particular it should be noted that Rock Creek drains a currently inactive coal mining site that includes bare soils and rock outcroppings. In addition, in the future Rock Creek will also receive surface water flows from several large planned developments in the watershed. Unfortunately, specific conductivity and total alkalinity were not measured before 2006, so a long-term comparison cannot be made to the time period before or during the time that the experimental sewage treatment plant was operating.

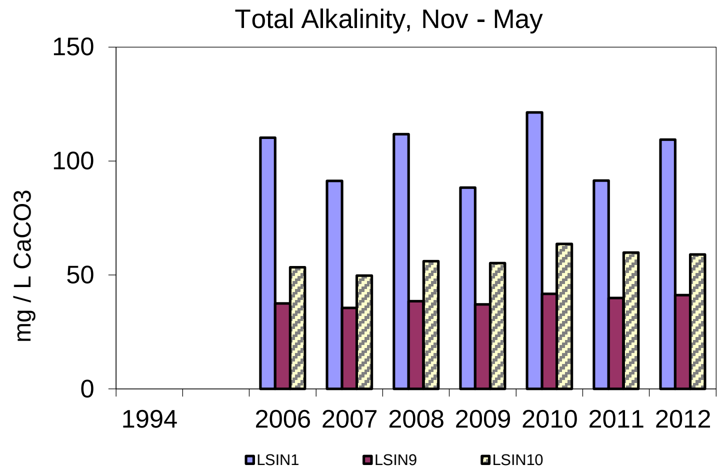

Figure 10. Wet season average of total alkalinity for Lake Sawyer and inlets

Total alkalinity, which is a measurement of the acid buffering capacity of the water, follows the same general pattern as specific conductivity (Figure 10). Alkalinity in the lake is higher than in Ravensdale Creek, but significantly lower than Rock Creek. Alkalinity values can be impacted by development of forested land due to factors such as ongoing leaching of concrete structures, soil horizon disturbances, and emplacement of foreign materials as fill to contour landscapes. As development proceeds, monitoring will document changes in water alkalinity that should reflect the increased development as well as other activities in the basin.

Phosphorus

Inputs of both total phosphorus and orthophosphate were also measured on a monthly basis from November through May. Total phosphorus is a measure of all phosphorus in a water sample in both dissolved and particulate forms, while orthophosphate is comprised of dissolved, inorganic phosphate that is readily available for immediate uptake as a nutrient for algae and aquatic plants. While theoretically most phosphorus could be available for biological growth over time if it were all converted to orthophosphate on entering the lake, in reality a certain amount entering the lake is likely to be buried in the sediments and never reach the water column in an available form, in addition to the portion that flows out of the lake through the outlet, particularly in winter when the lake the outflow volume is large.

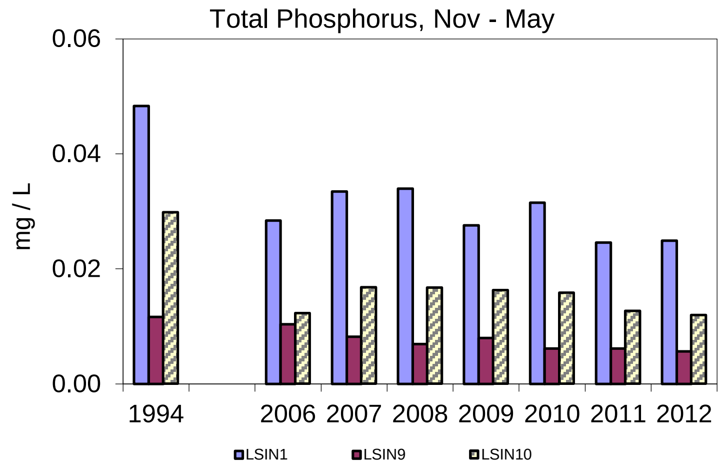

Figure 11. Wet season average of total phosphorus values for Lake Sawyer and inlets

Total phosphorus is clearly lower at all three sampling sites when compared to the 1994 water year (Figure 11), but the most dramatic decline is in Rock Creek (LSIN01), consistent with the diversion of sewage effluent from the wetland, as called for in the TMDL for phosphorus reduction. A significant decline has occurred in the Lake Sawyer outlet (LSIN10) as well, and this may reflect a decrease in the pool of internally loaded phosphorus recycled internally with the fall overturn. However, this data represents winter flows and lake concentrations, while the state-adopted TMDL does not define the time period to be used for evaluation.

There is a well-documented relationship between winter phosphorus concentrations in temperate lakes and spring/summer algae production, correlated well enough that winter P values may be used to predict algae production the next growing season. There is a lag time for most Pacific Northwest lakes between when the most phosphorus enters lakes (winter) and when it is utilized (summer). This is due to the seasonal variation in climate, which delivers most inflow to water bodies during the winter, while summer tends to produce very low base inflows with little water delivery to lakes, as well as little outflow. The result is that summer nutrient inputs may actually be very small, even though the concentrations in the inlet waters may be high due to groundwater influence. Thus, the decrease in winter phosphorus concentrations is a good indicator for Lake Sawyer, suggesting that algae may also be reduced. The data collected so far are encouraging in terms of the future prognosis for the lake.

A similar pattern was found for orthophosphate (OPO4, Figure 12). The variation between years can be expected based on precipitation patterns, flows, and their relation to sampling dates. Trends generally cannot be reliably calculated until a minimum of 8 consecutive years of data have been collected; however, the 7 years collected to date suggest that no trend is developing to-date for any of the sample locations. In 2012, the OPO4 average was lower than in 2011 for all three stations.

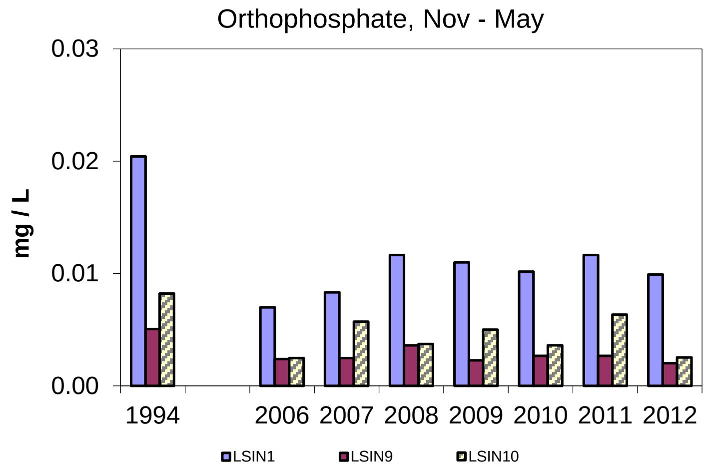

Figure 12. Wet season average of orthophosphate for Lake Sawyer and inlets

Storm water samples

The technical services contract between Black Diamond and King County called for sampling 1–2 storm events each year during November–May, but in the past it has been difficult to match up periods when storm criteria are being met with volunteer availability and the operational hours of the King County Environmental Laboratory.

Beginning in 2010, staff from the city of Black Diamond agreed to sample stream sites if a precipitation event met the storm criteria, and this resulted in 4 storm events sampled since then at seven sites (Figure 13). Storm samples were taken by collecting a single grab sample from each site as soon as possible after the criterion of approximately 1' of rain in 24 hours had been met and the creeks are flowing freely.

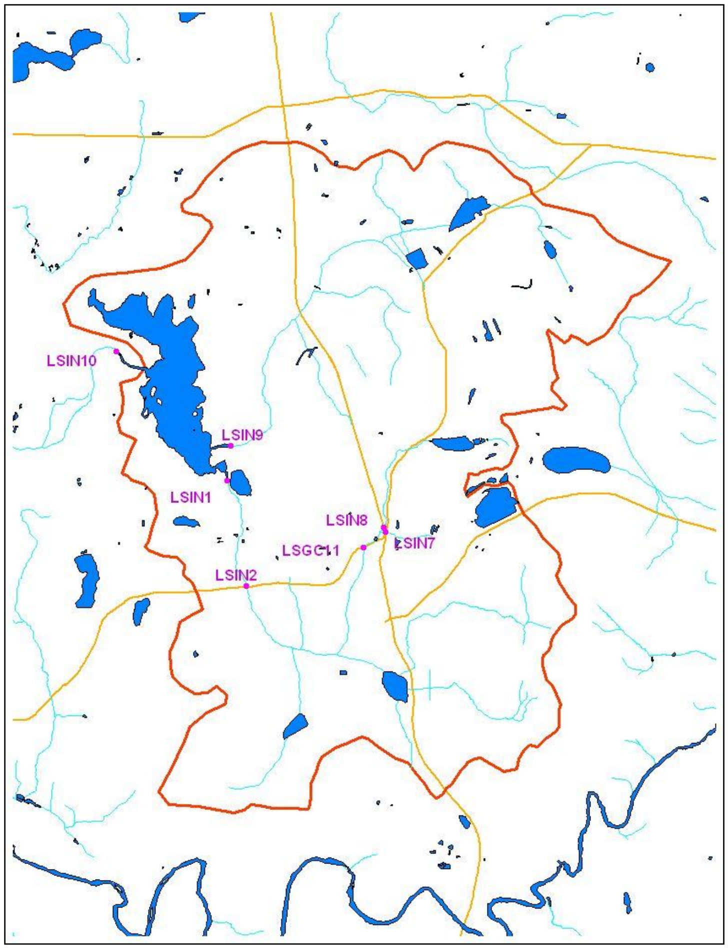

Figure 13. Location of storm sample sites on Ginder Creek, Rock Creek, Ravensdale Creek and the Lake Sawyer outlet

The measured parameters were the same as for the routine sampling, with the addition of "Hem: oil and grease" measurements (Hem stands for hexane extractable materials) at 3 stations: LSIN1 (mouth of Rock Creek), LSIN9 (mouth of Ravensdale Creek), and LSIN10 (outlet of Lake Sawyer). Sample values from all three sites have been below or just barely above the minimum detection level for all events sampled. This suggests that there are no extraordinary sources of oil and grease to the surface water during the storm events measured to date. At present, there are no state water quality standards for oil and grease concentrations.

The following discussion includes the data from 6 storm events, sampled between 2006 and the end of 2012.

In Figure 14 below and all subsequent figures representing storm samples, the dark blue bar represents the outlet from Lake Sawyer, while light blue is the station at the mouth of Ravensdale Creek flowing into the lake. The yellow, orange, and brown bars represent tributaries and stations along Rock Creek's path from upstream down to the mouth, beginning at the Ginder Creek crossing under Highway 169 (site LSIN8 and tributary LSIN7 just before it enters Ginder), downstream to the crossing under Roberts Drive (LSCG11) flowing south. Rock Creek site (LSIN2) is at the crossing under Roberts

Drive, flowing north to Lake Sawyer through a series of wetlands, while LSIN1 is the routine monitoring site at the mouth just before Rock Creek empties into Lake Sawyer. See the map in Figure 13 for location on a map.

Total alkalinity and Specific Conductivity

Comparing values among stations for alkalinity or specific conductivity can point to a particular stretch of waterway where inputs are entering the stream from increased development or soil disturbance. A jump in value for either of these parameters can occur in stormwater running over surfaces in developed areas or exposed soils and subsoils.

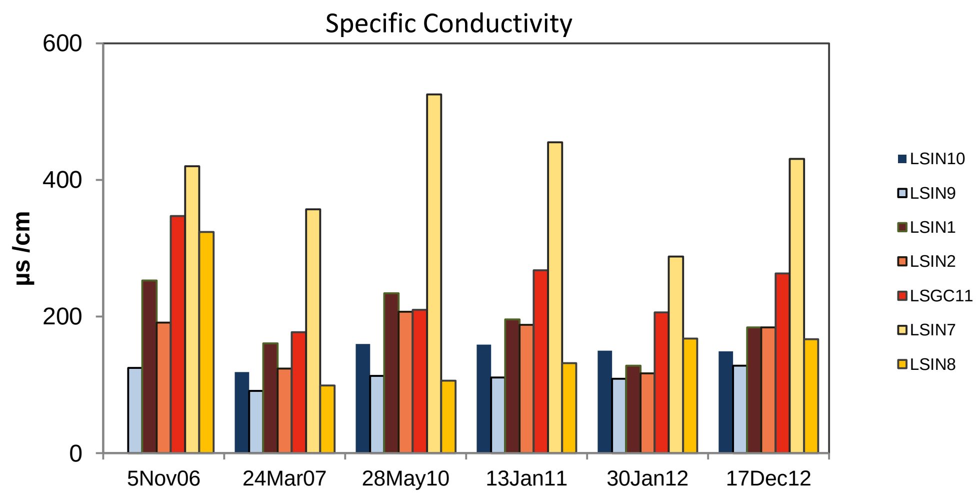

Figure 14. Specific Conductivity at 7 sites for 6 storm events in the Lake Sawyer watershed.

There is a distinct pattern reflected in all of the storm events, even though storm sampling by taking single grab samples can be notoriously variable in results (Figure 14). LSIN7 consistently has the highest value in each event, which likely relates to soil exposure on the area around the mine site that it drains. When this combines with water with lower specific conductivity in Ginder Creek (LSIN8) , the resulting water is between the two upper stations in value (LSGC11), but generally still higher than LSIN2 (downstream at Roberts Drive), which includes water from three other tributaries that dilute the Ginder Creek input. In 5 of the 6 storms, there was an increase in conductivity between LSIN2 and LSIN1, and this could be related to the creek flowing through a large gravel operations site between the two sampling stations. Ravensdale Creek water consistently had the least specific conductivity of all the storm sampling sites.

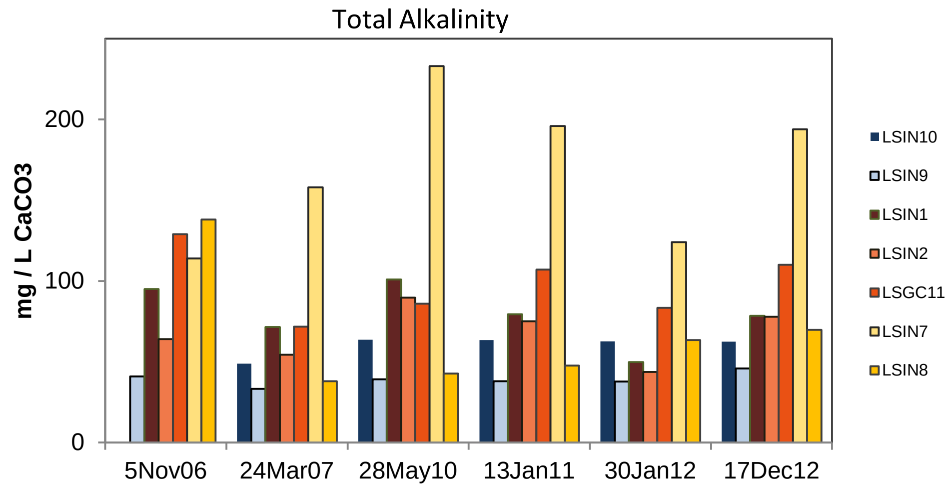

Figure 15. Total Alkalinity at 7 sites for 6 storm events in the Lake Sawyer watershed.

Total alkalinity (also called "acid neutralizing capacity") tells a generally similar story (Figure 15), with the difference that in the 2006 event, higher alkalinity was measured in the upper Ginder Creek sample (LSIN8) than the mine site tributary (LSIN7). However, in subsequent storms upper Ginder was consistently quite low in alkalinity. A disturbance above the confluence or an unusual input related to the storm may have been responsible for the high value in upper Ginder in 2006. It is interesting that, while the conductivity for the 2006 event was not higher in LSIN8 than in LSIN7, it still was unusually high, so the two measurements tell a similar story for the 2006 event. The relationships between LSIN1 and LSIN2 are also generally the same for total alkalinity as they were for specific conductivity.

Total Suspended Solids

Measuring total suspended solids indicates the amount of particulate material carried in the water. It can be especially high during storm events through erosion of banks or side channels by increased flows, as well as through excess runoff flowing over the surface instead of infiltrating soils, and picking up particles as it moves. Increases in nutrients carried by streams during storms are often attributable to the content of suspended solids in the water. Wetlands and stormwater facilities are generally designed with the idea of detaining water long enough to allow the suspended solids load to settle out of the water before flowing out of the facility downstream, thus removing a portion of the nutrient load before the water enters a lake or other receiving body of water.

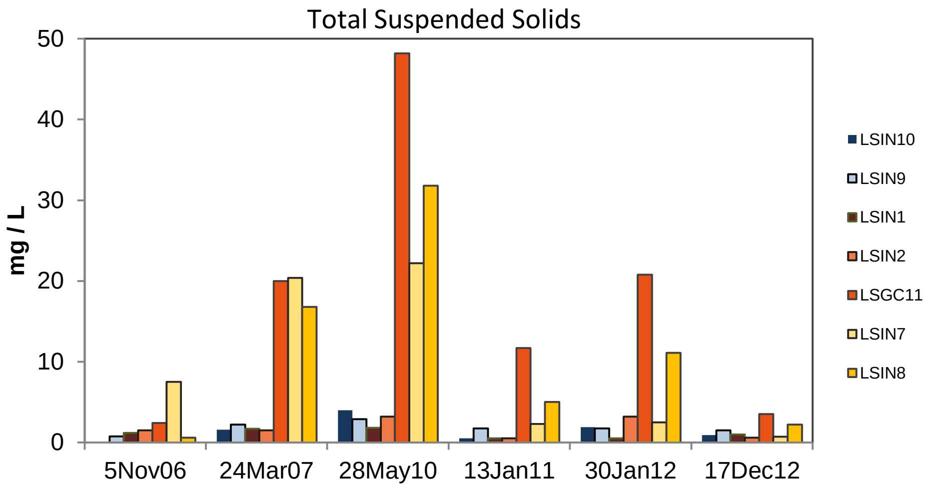

Figure 16. Total suspended solids at 7 sites for 6 storm events in the Lake Sawyer watershed.

Data from storm events in the Lake Sawyer watershed (Figure 16) are consistent with these processes. While there is a wide range in the amount of suspended solids in the creeks during storm events, the samples from stations along Ginder Creek in the upper watershed consistently carry a higher sediment load than samples from the Rock Creek stations located in the flat, wetland-dominated lower portion of the creek close to entering the lake. Either the other inlets are diluting the heavily laden waters of Ginder Creek before reaching the LSIN2 station or the wetlands are serving the function of detaining water long enough for sediment to fall out of suspension, thus reducing the input to Lake Sawyer. An interesting result from the May 28, 2010 storm is that the sediment load in the lake water is actually higher than in either Ravensdale or Rock Creeks, probably due to planktonic algae populations in the lake water.

Phosphorus

Both total phosphorus and orthophosphate were measured for storm events. In general, for storm samples the amount of total phosphorus varies in relationship with the amount of total suspended solids in the water. Orthophosphate is essentially independent of suspended materials and should vary less with storm-induced erosion, although it will vary to some degree with water source: surface runoff, direct precipitation and groundwater.

While all of the Ginder and Rock Creek samples are higher in phosphorus than the Ravensdale Creek samples (Figure 17), the pattern between stations along the Rock Creek drainage is not as consistent as it was for total suspended solids. It is possible that there may be a change in make-up of the sediments between the stations, with some upper stations carrying more large inorganic particles than the lower stations in the watershed, because of differences in rates of settling. Fine organic particles are often lighter and do not settle as quickly as mineral or rock fragments when water velocities decrease. However, this cannot be determined without measuring total organic carbon for each sample, which was not done.

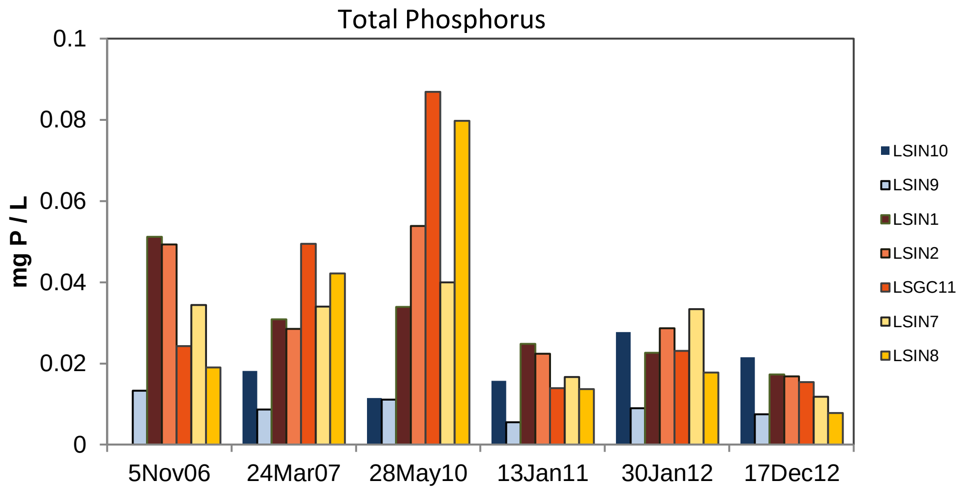

Figure 17. Total phosphorus at 7 sites for 6 storm events in the Lake Sawyer watershed.

It is interesting to note that the 2006 and the 2011-12 storms show a pattern of increase as the samples move from the upper to lower reaches of the Rock Creek system, while the reverse is shown for 2007 and 2010. There could be some relationship to the timing of the grab samples in relationship to the storm hydrograph or that a pulse of peak erosion was captured by the sampling. There could also be some relationship to soil disturbances going on in the sub-basins.

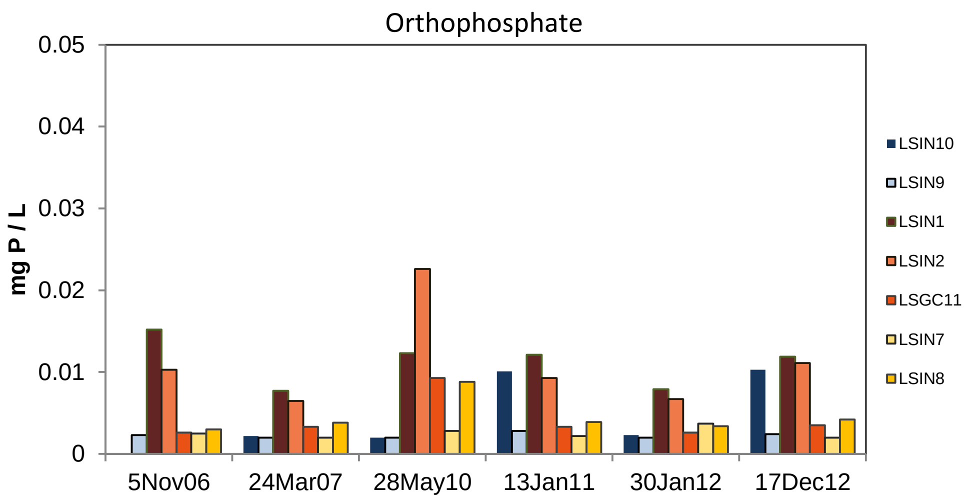

Figure 18. Orthophosphate at 7 sites for 6 storm events in the lake Sawyer watershed

Orthophosphate concentrations were lower than total phosphorus for all of the storm samples (Figure18). It was lower in concentrations in the water from the Ginder Creek stations than in the downstream Rock Creek stations. The wetlands may be releasing some orthophosphate to the creek that contributes to the higher concentrations. The high phosphate values in the lake outlet in the January and December samples are characteristic of water from lakes in mid-winter when there are small numbers of algae present and the lake is thermally mixed.

Conclusions and Recommendations

Based on May–October monitoring data, water quality in Lake Sawyer has appeared to be relatively stable over the last decade. The nutrients in the lake varied a small amount during the sampling season, and the N:P ratios were generally around 25 - 30 in 2012, which indicated that nutrient conditions in the lake could have been favorable for bluegreen algae blooms, but the overall low concentrations of phosphorus may have kept major blooms from forming.

The inlets have showed a decline in phosphorus since the 1990s, but more years of data should be collected to analyze for long term annual trends. Baseline values of total alkalinity and specific conductivity are being set to use as references as development in the watershed occurs. Continued monitoring should be carried out to assess conditions and to ensure that water quality remains consistent in Lake Sawyer as the area continues to be developed.

Storm sampling carried out to date suggests that more erosion is taking place during storms in the upper watershed of Ginder Creek than in the lower portion of Rock Creek, particularly from the tributary flowing from the mine site property. However, the flat topography of the downstream portion of Rock Creek may be catching some of the sediments before they enter the lake. More bioavailable orthophosphate may be released from the wetlands than from the upstream portions of the watershed. It appears from three storm samples that hexane-extractable oil and grease may not be a concern at this time.